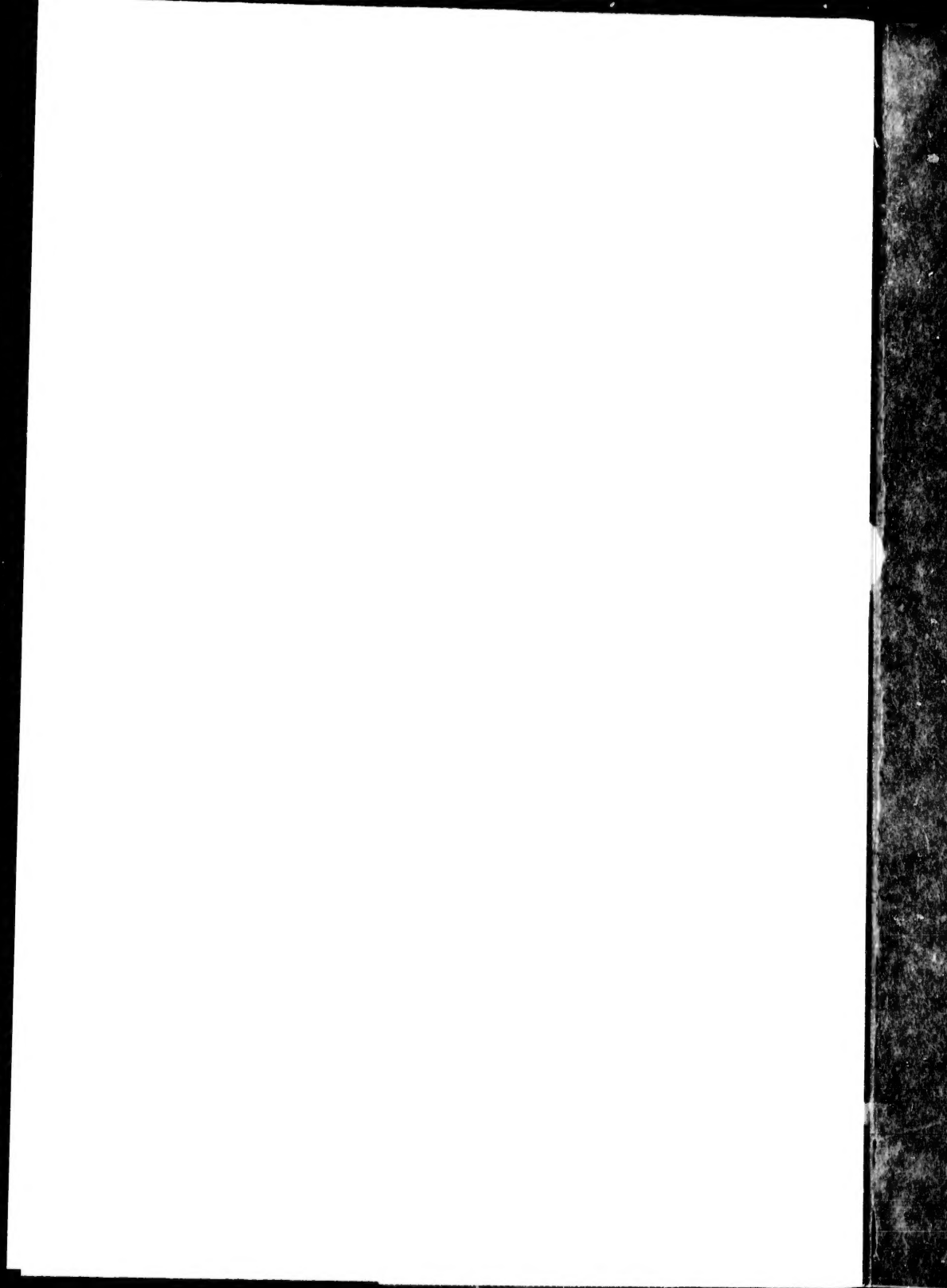
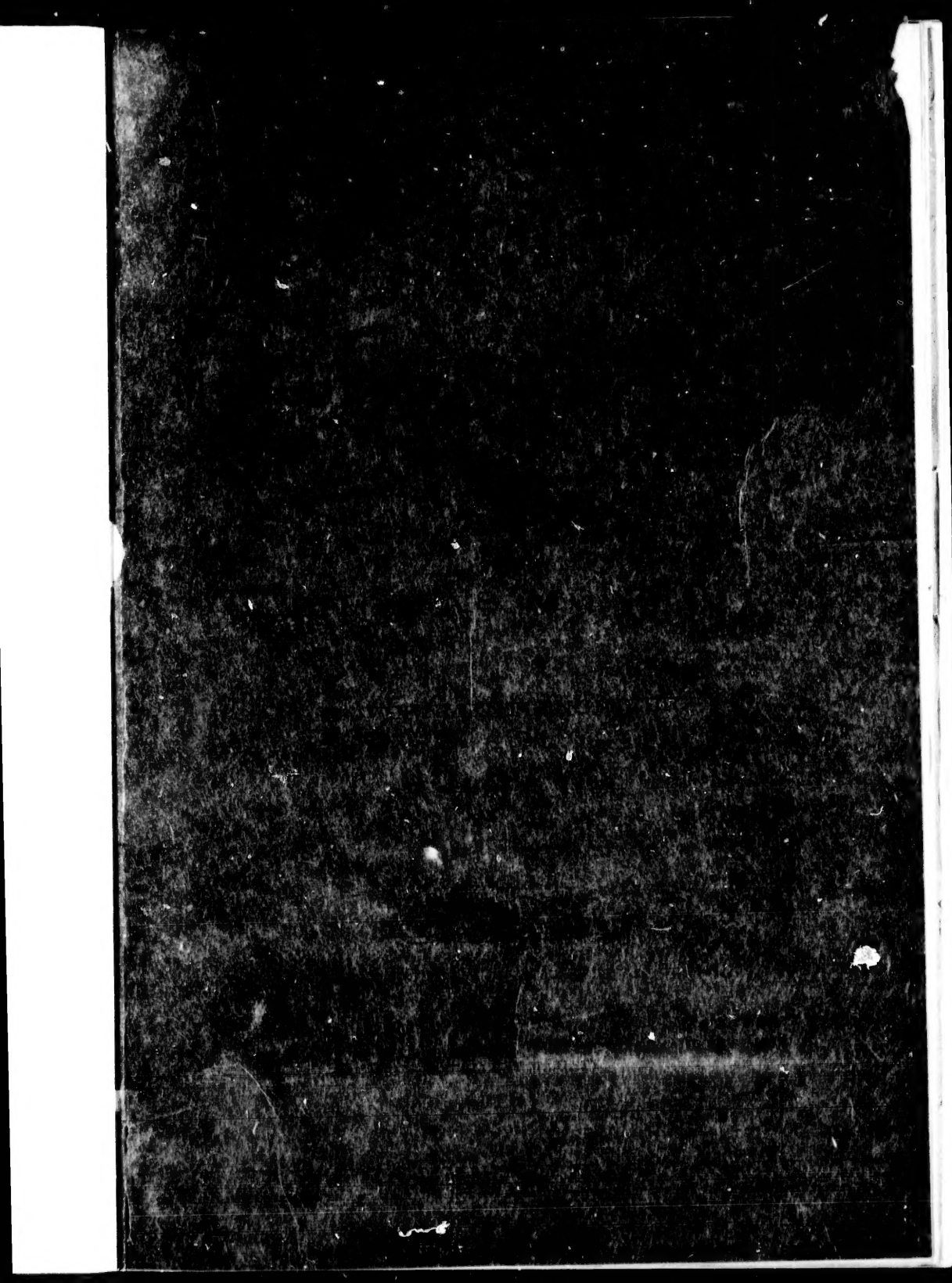






RETURN

(62a)

To an Order of the House of Commons, dated the 1st July, 1891, for a Copy of the Report of Thomas Monro, Government Engineer, upon the Manchester Ship Canal.

By order.

J. A. CHAPLEAU,
Secretary of State.

REPORT ON THE MANCHESTER SHIP CANAL.

SOULANGES CANAL, ENGINEER'S OFFICE,
COTEAU LANDING, 14th May, 1891.

SIR,—Referring to the accompanying extract from an Order in Council dated 24th December, 1890, and your letter of instructions dated the 13th January, 1891, I beg to enclose herewith a Report embodying the result of my examination of the Manchester Ship Canal, in the month of February of this year, together with some observations on the general subject of canal construction.

Pressure of business has prevented my submitting this document at an earlier date; and, as you are aware, the ship canal is of such vast extent as rendered it impossible to do more than accomplish a rapid inspection of its chief points, in the limited time at my disposal. It is hoped, however, that the Report may be of some value in directing attention to several matters connected with the construction of hydraulic works on which more extended discussion seems desirable.

I am, sir, your obedient servant,
THOMAS MONRO, *M. Inst. C.E., &c.*

A. P. BRADLEY, Esq.,
Secretary of Railways and Canals, Ottawa.

EXTRACT from a certified copy of a Report of a Committee of the Honourable the Privy Council, approved by His Excellency the Governor General in Council on the 24th December, 1890.

On a memorandum dated 20th December, 1890, from the Minister of Railways and Canals, representing that there has been strongly suggested to him by the Chief Engineer of Canals, the expediency, in view of the Dominion Canal works enlargement now in progress and contemplation, of obtaining by actual inspection, through one of its engineers, of some of the great works of canal construction now going on in England, a practical knowledge of the latest means and machinery adopted both for the construction and operation of canals built on the large scale of the present day; and a most favourable opportunity being now afforded in the construction of the great engineering work, the "Liverpool and Manchester Ship Canal," in which it is understood that the most recent improvements are being and will be adopted; it is proposed that Mr. Thomas Monro, an engineer of the Department of Railways and Canals, be sent over for the purpose of acquiring the information to be obtained in this connection—time to be spent in England not to exceed five weeks.

The Minister concurring in this suggestion recommends that authority be given accordingly.

The Committee submit the same for Your Excellency's approval.

JOHN J. MCGEE, *Clerk Privy Council.*

To the Right Honourable The Minister of Railways and Canals.

REPORT ON THE MANCHESTER SHIP CANAL.

The completion of the ship canal will make Manchester practically a seaport. Vessels of the largest size will be enabled to ascend from the tidal estuary of the Mersey and discharge cargoes from all parts of the world in the capacious docks and basins now nearly completed at Salford, 35½ miles inland.

This great scheme owes its origin to the business foresight, energy and wealth of Manchester; its main object being to cheapen freights by avoiding the excessive harbour dues of Liverpool—the cost of extra handling and cartage—and the heavy railway charges on goods between that city and Manchester. From the beginning of the enterprise it has been considered by its promoters an established fact that, when the canal is opened for traffic, rates of freight and marine insurance on foreign consignments to Manchester will not exceed those to Liverpool; and the saving thus effected will be available for division between the Canal Company and the owners of cargoes. The probable proceeds from this source will, it is stated, provide remunerative rates for the company, and result in a saving of at least 50 per cent. (see appendix) on the present average cost of transportation between the two cities.

The importance of such a reduction cannot be over-estimated, especially in the present condition of trade. The very existence of numerous industries in the districts around Manchester is dependent upon cheap transportation, now that the rate of carriage bears, in many cases, such a disproportionate relation to the cost of the commodities themselves. It is said that the dues at the ports of northern Europe, and the canal and railway rates between these ports and the interior (especially in Belgium) are so very much less than those which the trades of the Manchester districts have to pay, that all their industries are greatly overweighed in the competition which they have to meet; whereas the ship canal, when built, will go far to place them in as good a position as their continental rivals.

In brief, distance from the seaboard is now exercising a marked effect upon the prosperity of hitherto flourishing inland towns. Proximity to the coast means progress, whereas long railway carriage to a shipping point, with its attendant cost, will practically put a manufacturing centre out of the race in these days of fierce competition and narrow margins.

These statements are irrefutable; and the magnitude of the interests involved in the construction of the work in question may be conjectured from the fact that within a radius of 45 miles from Manchester there is a population of nearly eight millions chiefly engaged in manufactures. The prospective traffic of the canal during the second year after its being opened is estimated at about 4,500,000 tons, the revenue from which, would enable at least a four per cent. dividend to be paid on a capital of £10,000,000 and leave a considerable surplus for reserve or sinking fund.

As might have been expected, this enterprise was strenuously opposed from its inception both by the Dock Board and Corporation of Liverpool, and the various railway companies interested. About £150,000 had to be spent by its promoters before the Acts authorizing construction on the present plan were passed; and even now the works are hampered with conditions which have greatly increased the cost of the undertaking and may injuriously affect the future operation of the canal.

If, however, the scheme is successfully carried out, it will afford a striking example of what a great English manufacturing town can do, relying solely upon its own resources, and wholly without Governmental aid. Its construction will also afford another proof of the fact that no railway can compete with a canal of large dimensions in the cheap carriage of heavy goods. It is stated that even the Bridgewater Canal (navigated by barges of only about 50 tons) carries 60,000 tons of traffic per mile per annum, whilst the average of the railways of England and Wales is only 17,000 tons. It pays a larger dividend than any railway in the country, and has been recently acquired by the Manchester Ship Canal Company at a cost of £1,750,000. The Leeds and Liverpool Canal, worked independently of the railways, pays an average dividend of over 18 per cent.

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The history of the inception and progress, so far, of the Manchester Ship Canal is very interesting and instructive. The capital originally considered as being amply sufficient for all purposes connected with the entire completion of the undertaking was (in November, 1886) set down by an advisory committee composed of able and experienced men at \$9,812,000. It was then stated that the cost of the works would not exceed £5,750,000, and that the sum of £802,936 should pay for all land and damages. The Bridgewater Canal to be acquired for the sum above mentioned, the average net income from this being set down at £60,000 per annum. Forty thousand shareholders showed what confidence the public had in the scheme; and for the first three years after the commencement of the works, the progress made was almost unparalleled. But the death of the contractor, Mr. Thomas A. Walker, had an immediate effect upon this rapid rate of progress: the works were not so vigorously pushed, although they were to have been completed, under a heavy penalty, in three years. Then the rate of wages advanced from 20 to 25 per cent.—the winter frosts of 1890 were phenomenally severe, and the heavy floods of November did much damage. The result of all this was, that, on the 24th November, 1890, the directors decided to take over the works upon certain conditions, and in this way avoid litigation with the trustees of the contractor's estate, as well as place themselves in a position to carry on operations untrammelled by the existence of any contract whatever.

At a half yearly meeting of the shareholders, held in Manchester on the 4th February last, this action was unanimously approved;—although only generally known then for the first time. In readjusting matters connected with Walker's contract (understood to have been originally for the sum of £5,750,000, with schedule prices attached) an addition to this amount was granted, for extras and unforeseen items, of £865,753, (see Appendix) whilst that expended for land and damages up to date was found to be £1,022,390. In short, the funds were confessedly exhausted, and the announcement was authoritatively made that unless relief were at once forthcoming, operations must soon entirely cease. An appeal for help was made to the Corporation of Manchester, which was promptly and cordially responded to. Estimates were made by the engineers of the company, showing that the additional sum required to complete was, say, £1,700,000; but before extending the promised aid the Corporation wisely had an independent enquiry made by their own engineer, which resulted in this amount being increased to about £2,500,000. Steps were taken to obtain the requisite permission from Parliament to advance the money. This power will be granted almost as a matter of course. Thus this immense undertaking will probably be completed at a cost of about £12,500,000; or, say, \$62,500,000—a much larger sum than that hitherto expended on all the Canadian canals, which is shown in the last Report of the Department to have been, up to the 30th of June, 1889—\$54,596,188.

There are, however, physical difficulties to be contended with in the operation of this canal, which may prove more formidable than those of financial origin already experienced. Indeed, of the Manchester Ship Canal, as a line of navigation suitable for ocean vessels, it may be said that it is an experiment on a gigantic scale—one which it is hoped may fully realize the expectations of its supporters—but still an experiment, because there are conditions met with which it is believed do not exist elsewhere in the same degree on a first-class line of navigation.

For example; the admission of tidal fluctuations into the lower two-thirds of a lock canal must prove a source of trouble in the movements of the large class of vessels which it is intended to accommodate. It is also obvious that the upper or inland portion between Latchford and Manchester, which absolutely takes the place of the Rivers Irwell and Mersey and their tributaries, will act as the main drain for a large area of country, and must be subject to sudden and objectionable variations of level. The surplus waters of this region hitherto found their way slowly along the winding courses of the rivers to the estuary, periodically flooding large areas of land along their margin. Now, however, the straight and deep line of "canalised river" will quickly carry all this off. It is said that during the heavy

floods of last November, about 30,000 cubic feet per second was the maximum flow into the canal over the weir at Throstles' Nest near Manchester. The rate of current which must ensue from the passage of even one-half of such a volume as this cannot but be serious even when the canal is completed to its full cross-section throughout and all the sluices are in position. These difficulties will, of course, be only of short duration and experienced at considerable intervals; still, when combined with those of the tide, they will render the navigation much more difficult than that of the Welland or St. Lawrence Canals, where each is arranged to admit just as much water as is required for satisfactory operation and no more. The fluctuations of the lakes and rivers do not seriously interfere with their safe working and the lower entrances are not embarrassed by the continuous oscillations of tides. It may be said, at this point, that the effective, rapid, and safe navigation, through lock canals, of vessels of 2,000 tons is no longer a problem for solution in Canada. The practical experience possessed on this point does not, however, exist in England, where up to the present time, the largest navigation has been for barges of about 300 tons—but by far the greater length of the aggregate of 3,000 miles of canal, said to exist in the United Kingdom, is for boats ranging from 25 to 50 tons burthen.

There are, however, some points in the construction of the Manchester Ship Canal which are worthy of full consideration. These will be alluded to in their proper order.

With these few prefatory remarks it is now proposed to briefly describe the canal, its structures, arrangements for its future operation, &c., &c. The following description is taken chiefly from a paper printed for circulation when the Fourth International Congress on Inland Navigation was held at Manchester last year. A copy of this paper was furnished by Mr. Williams, M. Inst. C. E., Engineer to the Canal Company; and is the only document obtained from him during the time of the examination.

The line of the Ship Canal leaves the Mersey at Eastham, a point on the south shore of the estuary six miles above Liverpool, and where a deep water channel approaches the lower entrance. It is intended to dredge there to a depth of 30 feet at neap, and 40 feet at spring tides, so that large vessels can enter the canal during a great part of each tide; and vessels of moderate draught almost the whole of each tide.

At Eastham there are three entrance locks side by side, of the following sizes in the chamber (1) 600 feet by 80 feet; (2) 350 feet by 50 feet; (3) 150 feet by 30 feet. There are also two sluices of 20 feet wide each for assisting in filling the canal—the surface level of which will be 14 feet 2 inches above the old dock sill at Liverpool, or about the level of mean high water.

At all tides above the ordinary level of the canal, all the lock-gates at Eastham are intended to be open. Spring tides will rise from 5 to 7 feet over ordinary level of the canal in its tidal portion, which extends to the next group of locks at Latchford, a distance of about twenty-one miles.

The length of the canal is, as before stated, thirty-five and a-half miles. From Latchford to Manchester, fourteen and a-half miles, it will be filled with the waters of the Mersey, Irwell and other rivers. The level of canal surface is arranged so as to take all the water, and thus form the main drain for a very large extent of country. Therefore, at each set of locks, large sluices are provided to deal with the flood and surface water. Steps are being taken to purify the waters entering the canal, which are now in a very polluted condition.

From Eastham, the canal is for 12 miles of the distance inland, and nine miles along the estuary. Embankments are, therefore, formed across the bays, &c. Where the foundation is clay, these are formed of clay hearting protected by heavy stone work. In some places where the bases of the embankments are on sand, close piling is driven on each side at the foot. At Runcorn a sea wall of concrete is being built instead of an embankment.

In addition to the locks and sluices at Eastham, and in order to permit of the tide flowing freely into and out of the first reach of the canal, two openings, each about 600 feet wide, have been formed in the north bank. One of these is at Ellesmere Port and another alongside the sluices opposite the River Weaver. There are ten of these sluices, 30 feet wide, to allow the water of that river to pass out of the canal. The sluices will also be used for tidal flow.

The canal passes Runcorn under the viaduct of the London and North-Western Railway, and leaves the Mersey by a deep cutting, approaching it again at "Old Randles," where two 30-foot sluices have been built to enable the tidal water to be let into or out of the canal.

Between Eastham and Latchford, the minimum width of the canal at bottom is 120 feet. The depth at mean high water is 26 feet. The surface width varies with the side slopes. The lock sills are placed 28 feet below water level, to allow of a future deepening of the canal by dredging.

At Latchford there are two locks side by side—the larger one being 600 feet by 65 and the smaller one 350 feet by 45. At Irlam, seven and a-half miles above Latchford, similar locks are nearly constructed, as well as at Barton, two miles above Irlam, and at Mode Wheel, three and a quarter miles from Barton. These last-named locks form the entrance to the Manchester Docks, which extend one and a quarter miles above Mode Wheel.

The total rise from the ordinary water level of the canal at Eastham to the docks at Manchester is 60 feet 6 inches. This rise, divided amongst four locks gives an average of about 15 feet $1\frac{1}{2}$ inches. All the lock gates are constructed of greenheart, a very hard wood imported from Demerara, which has been found by experience to be exceedingly durable; and the gates are said to be less liable to damage than those made of iron. The gates are worked by hydraulic power, provided at each set of locks, the engines and machinery of which are being constructed by Sir W. G. Armstrong, Mitchell & Co.

To let off the flood and surplus water, sluices on Stoney's patent are provided at each set of locks. These are 30 feet wide each. There are four at Mode Wheel and Barton, and five at Irlam. At Latchford there are only three; as the flood waters of the Mersey will flow down the river channel through Warrington, from the point above Latchford where the canal leaves the river and takes an independent course inland.

The railways are crossed over the canals by high level bridges. Of these there are five, viz:—The London & North-Western; The Great Western; Warrington & Stockport (2) and Cheshire Lines (Liverpool and Manchester). The clear headway for the railway bridges is 75 feet, which is the height of the underside of the Runcorn viaduct over the water in the canal. The total length of railway diversions is eleven and a quarter miles, and the viaducts are mostly on the skew with openings varying from 266 to 137 feet. In some cases a new line had to be formed on each side of the canal to the new crossing. From this it will be observed that the question of railway diversion was a formidable one to deal with, and added greatly to the cost of the undertaking. The embankments of approach are very high and swallowed up vast quantities of material.

There are two high level and six swing road bridges between Runcorn and Barton. The spans of these bridges are in all cases not less than 120 feet, the full navigable width of canal being retained. The minimum headway is the same as for the railway bridges.

The swing bridges will be worked by hydraulic power, as well as the moveable aqueduct which will enable boats to pass across the Ship Canal at Barton. This will have two openings of 90 feet each which will be crossed by a long iron caisson or trough resting on a central pier. This will be filled with water to the same depth as the Bridgewater Canal, and boats will pass through it over the Ship Canal. The caisson can be manoeuvred like a swing bridge when required—the water being retained in it by lifting gates at each end. Similar gates will cross the Bridgewater Canal at the approach to this caisson to retain the water

in that canal when the aqueduct is open. The docks at Manchester will have an area of water space of 114 acres; the area of quay space being 152 acres. The length of quays will be $5\frac{1}{2}$ miles. At Warrington, a dock is proposed to be constructed of an area of 23 acres. At Partington the canal is widened out to allow steamers to lie on either side; and branch railways will be constructed with hydraulic coal tips to accommodate the trade.

With the use of the electric light the canal can be navigated at night. It is expected that the whole length of the canal can be traversed in about ten (10) hours.

The canal passes through either red sandstone, rock or marl; alluvial deposits of clay, gravel, sand or loam overlying the sandstone rock. These strata have been favourable for the work in some respects, as the rock where suitable is used for pitching the slopes of the canal where the soil is soft and requires protection from the wash of steamers; or for buildings or concrete. Excellent clay for bricks has been found, and 450,000 bricks per week have been made at the contractor's brick-yard near Thelwall. Large quantities have also to be bought, as about 70,000,000 will be used on the canal. The gravel and sand are being used for concrete, of which 1,250,000 (a million and a quarter) yards are required.

Concrete has been used wherever practicable in dock and lock walls. The copings and hollow quoins are of Cornish granite, while hard sandstone from quarries in Yorkshire, Derbyshire and Cheshire, and limestone from Wales, are used in other portions of the work. The lower portions of the dock and lock walls are formed of concrete. At the water level, granite or limestone fender courses slightly projecting from the face of the wall are inserted to protect the concrete. Above this level the concrete walls are faced with brickwork. Culverts are built in the upper parts of the dock walls for hydraulic and gas mains. All the brick work is faced with blue bricks. The total amount of brick work required is 175,000 cubic yards, in addition to 220,000 cubic yards of masonry.

For the excavation of the canal nearly 100 steam excavators of various types have been employed, (some of which have been constructed in France and Germany) and to convey the earth to the spoil grounds and for other purposes there were employed in 1890, 173 small locomotives; 6,300 waggons and trucks; 223 miles of railway (4 feet $8\frac{1}{2}$ inches gauge) having been laid alongside of and in the bed of the canal.

The rate of excavation has varied from $\frac{3}{4}$ to $1\frac{1}{4}$ million cubic yards per month. As much as 2,400 cubic yards have been excavated in ten hours by the German excavators, but their average work would be less than 2,000 yards. Like the French type of excavators, they are land dredges suitable only for soft soil. The English excavators have in good soil at times reached nearly 2,000 cubic yards per day, but their average in all sorts would be about 700 cubic yards. They are, however, capable of excavating very hard material, and even rock where powder is used ahead of the excavator. There were 194 steam cranes, 182 portable and other steam engines and 209 steam pumps, employed upon the works, and they consumed about 10,000 tons of coal per month.

The deepest cutting is near Runcorn, where for a short distance the depth is 66 feet. The largest cutting is at Latchford, where for a distance of $1\frac{1}{2}$ miles the depth averages 55 feet.

The slopes of the cuttings vary with the nature of the soil from 1 to 1 to 2 to 1. In the rock cutting the sides are nearly vertical.

The total amount of excavation is about 46,000,000 cubic yards; 10,000,000 of which is sandstone rock. The spoil from the Canal is used in filling up the river bends which are cut off by the Canal and in raising the low-lying lands near by, so as to make them available for use as shipyards and other purposes.

Of the $35\frac{1}{2}$ miles of canal, 15 are curved and $20\frac{1}{2}$ straight line. The sharpest curve is at Runcorn, and has a radius of 30 chains (1,980').

It is not considered necessary, for the purposes of this Report, to refer in detail to the small navigations tributary to the Ship Canal, further than to say that they

will prove most valuable feeders to its trade. Neither is any particular reference required to the various railway crossings. They have added greatly to the cost of the Canal, and it is said that the railway companies (who were all along antagonistic to the scheme) insisted on the various works connected with the deviation being carried out in the most costly manner. The viaducts are principally built of brick, and as they generally cross the canal on the skew, wide and expensive spans were necessary.

The above résumé of the principal items of work will give a pretty fair idea of the magnitude of the undertaking. It is now proposed to pass rapidly in review the chief points in construction as they presented themselves to the writer during the month of February last, the greater part of which was spent in making a close examination of the canal. It was traversed on foot from end to end, particular attention being given to the locks and other important structures.

The first feature which strikes the eye of a Canadian engineer is the absence of towing paths or berms in the cuttings, which are often fifty feet deep. The slope is generally steep and always continuous from top to bottom.

This plan has doubtless been adopted from economical motives; as it serves to lessen both the amount of excavation and the area of land required. But it is obviously a defective method of construction, as without towing paths or berms there is no way of stopping or mooring vessels in the cuts, or of passing along rapidly with means of help in case of collision or other accidents. It is also clear that in traversing the variety of soils above enumerated, there will be, in many cases, a tendency to slide which would be measurably diminished by the formation of a berm about halfway down the cutting, or near the level of ordinary water in the canal. As a matter of fact there have been numerous slides already, and means are being devised to prevent their recurrence on a more extended scale by filling up the gaps with stone, planting osiers, &c. The sandstone pitching of the slopes does not appear to be of a character to resist permanently the wash of ocean steamers, if they should perform the trip from Eastham to Manchester in the time expected, viz., 10 hours. It will probably take on an average three-quarters of an hour for a large ship to get through a lock and as there are five of these, the speed at which the Canal part of the voyage would have to be made would, even with the large cross-section of canal, create a wave that would probably peel off the pitching in many places. The general impression given was that the side slopes are too steep throughout.

As to the shifting of material, it is evident at a glance that perfect organization existed for the execution of that important part of the work. The contractor's equipment of locomotives, excavators, cars, steam pumps, railway tracks, lighting, huts for the workmen, and all the details connected with the operations showed a combination of skill and foresight which only long experience combined with rare ability could give. Some idea may be formed of the extent of the operations carried on by Mr. Walker, when it is stated that the value of the plant owned by him, on this contract alone, was valued at about a million sterling.

There is nothing particular to observe in the methods adopted of taking out either the rock or earth. The railway tracks have, it is said, a maximum incline of 1 in 30, which was found to be the practical limit of economical grades. The haul is in many cases very long—several miles, but from all that could be learned it does not appear that earth excavation costs on an average more than 30 cents per cubic yard. Reliable information on points connected with values was not, however, obtainable during the time of the writer's visit. This will be readily understood if the embarrassed state of the Company's affairs and the partial confusion consequent upon a sudden change of management are taken into consideration. This remark also applies to the difficulty experienced in trying to understand several

matters without such help as is usually afforded, principally owing to the fact that the time of the Engineer seemed to be almost wholly taken up in making estimates of work remaining to be done in order to fully complete the canal.

As previously stated, the sides of the rock cuts are nearly vertical from top to bottom. Some of these are so smooth that the sandstone looks as if it had been planed off. A very good idea of this can be formed by examining photograph No. 22, of the series attached, which shows admirably the wavy stratification of the rock in the cutting near Ince. The steam shovels used there were of sufficient power to remove the rock easily when loosened by blasting in advance of the machines. In some cases over 500 cubic yards of this material was taken out in ten hours. The Ruston Proctor machine seems to have been a favourite. Time would not permit of a close examination of the varieties employed on the work. A list of the manufacturers, is, however, appended to this report. The earth waggons were of a substantial class and in excellent condition. They hold about four cubic yards each—there being generally twenty cars to a train—sometimes more. The locomotives were of the usual contractors' type, costing from £1,000 to £1,250 each.

A large part of the earth was used to fill in the old river bed, as previously stated. In many places it was hauled in large quantities and for long distances to make up the new railway embankments; and in some places enormous spoil heaps are formed, one of which, near "Stanlow Cutting," appears to reach an elevation of about 100 feet over canal bottom. These features give an impression of magnitude somewhat like that produced on looking south from Allanburg through the deep cut on the Welland Canal. The rate of progress has been previously stated at an average of about one million cubic yards per month. This, it is said, was kept up for a considerable period. The force employed sometimes reached the large number of 20,000 men and boys. Small villages of huts were erected for their accommodation at convenient points along the Canal.

It is now proposed to look more in detail into various points of construction which may be found useful in considering future plans connected with the completion of our canals. The numerous drawings accompanying this report show clearly the dimensions of several of the locks and sluices, and a description of the chief features of one set will serve for all the rest.

All the locks and sluices on the canal are founded on red sandstone rock. This is, of course, a most important point, and must have largely contributed to save the works from more serious injury than they appear to have sustained during the floods of last November. The rock where it forms the chamber-floor is hollowed out into the shape of an invert. In several cases the walls were built before the central portion or core of rock was excavated; this serving, meanwhile, as available space on which to deposit materials, make roads, and, generally speaking, to get over the work, and thus save a large amount of labour in hoisting. The walls throughout are of concrete, with brick facing above the level of the lower reach. They are not designed of much greater thickness than the dimensions usually given to those of masonry. The width of the dividing wall between the two locks at Latchford, Irlam, Barton and Mode Wheel is about 30 feet, but it is pierced by filling culverts of large dimensions, one for each lock. The top width of the wall gives ample room for working operations. All the inland locks are arranged with a third or middle gate so as to economize water for filling, as well as facilitate the passage of vessels. The large lock, 600' x 65', can in this way be made 450' x 65' or 150' x 65'. The smaller lock alongside, 450' x 45', can be made either 330' x 45' or 120' x 45'; so that, in all, six different sized vessels may be served as occasion requires by two locks. The amount of feed saved will, of course, depend upon the total traffic and the proportion of small craft which will use the canal. The tendency in such a trade will, however, be towards an increased size of vessel. If it has been thought advisable to incur the expense of extra gates, mainly to save feed, it should be borne in mind that the demand for this must increase whilst the supply cannot be augmented except by storage, which in such a densely populated district would be a very costly

affair. It is said, however, that the supply is ample, and it is presumed that this question has been placed beyond a doubt. No such element enters into the calculations for our canals—their supply is constant and practically inexhaustible.

On the Ship Canal the upper gates are placed on a breast wall forming a horizontal arch. These gates are, therefore, not nearly so high as the lower ones. This is an old arrangement, and is obviously better than the present mode of having all the gates of the same height at each lock as on the New Welland and St. Lawrence Canals. Many of the accidents which occur in navigation arise from vessels striking the upper gates when closed on the reverse side of the mitre, by which they are pushed apart and then at once swept out of position by the rush of water—great damage being also generally done to the vessel, and sometimes to the reaches below. But with a breast wall, as on the Ship Canal, the upper gates are out of danger, because a vessel may strike the wall but cannot touch the gates, which are, therefore, safe from the fruitful source of damage alluded to. There is no timber whatever in the foundation of the locks or retaining walls. The mitre sill platforms are of stone, and the gates shut against massive sills of granite. By the introduction of masonry invert great stability is secured.

It is not necessary to describe the brick facing of the locks above the rubbing course of granite which is carried all round at about the level of the surface of the lower reach. Such a method of construction is entirely unsuited to our climate—and appears liable to be destroyed if struck heavily by a vessel. It is presumed, however, that the plan has been practically tested before being adopted in such an important position. As a general thing it may be said that all the works connected with the locks, sluices and other structures of the Manchester Ship Canal are executed in an excellent and workmanlike manner.

The group of locks at Eastham (the dimensions of which are previously given) is designed to meet the special requirements of navigation at the Mersey entrance, where the spring tides rise to from five to seven feet over ordinary level of the canal, or about 21 feet. During such times the gates will be open, the tide being permitted to flow freely into the canal. At flood, the gates will be shut and the water thus penned in, will, on the ebb, run out through the openings made for that purpose at Ellesmere Port, Runcorn, &c., and be used for locking up at Eastham. The water of the canal below Latchford will thus be more or less in a constant state of fluctuation or oscillation. What the effect of all this will be on the operation of the entrance gates or the navigation of the canal for ocean vessels cannot now be determined. As before stated, it is an experiment, the solution of which experience only will give.

The locks are filled by culverts formed in the side walls. The openings leading to these are in the recesses behind the gates, as shown in the various plans. The obvious advantages of this system are the rapidity with which the chamber can be filled without creating such objectionable currents as when this is done through valves in the gates, and also the important fact that by its adoption the gates themselves are not weakened by forming large openings in them, just where strength is most required. Culverts are not necessarily an element of weakness in the structure, and as the level of their bottoms can be made the same as that of the lock floor, it follows that when the chamber is emptied so are the culverts, which is not the case when they are constructed under the lock floor, and where in case of accident they have to be pumped out even after the lock is emptied. This increases the difficulty of unwatering when to do this rapidly is a matter of the greatest importance, as for example during the height of the navigation season, when trouble is most likely to arise. This is forcibly illustrated by the accident which happened at the Sault Ste. Marie Lock last season, where by far the greater part of the time was occupied in the unwatering below floor level whilst a whole fleet of vessels awaited the re-opening of navigation outside. It seems clear, therefore, that the plan of having culverts in the side walls in the manner adopted on the Ship Canal and numerous large works in England has a great many points to recommend it. It has been objected that in this climate the frost may be introduced by these openings into the

heart of the walls and have a damaging effect on the masonry. It does not appear that this view can be established. During the operation of the Canal, the culverts are, of course, always full and do not require to be emptied unless in case of accident or when the Canal is undergoing repairs in the spring, so that there is really no chance to damage the walls in the way apprehended. It seems as if our own Canal experience so far gives sufficient proof of the correctness of these views.

The lock gates on the Ship Canal (see plans) are of great strength—very heavy and costly. Indeed it would appear as if the same superabundance of strength which is generally seen in the structures of this canal culminated in the lock gates.

They are framed and put together in large sheds erected for the purpose. They are accurately fitted in all their parts, and the workmanship is of the very best kind. When completed in the shop, they are taken apart and transported to the works where they are set up in place. This, of course, adds to the cost, which is very large. It is said that one leaf of the gates of the large lock, at Eastham, will cost as much as a complete set for a lock on the Welland Canal, or about £3,500. The greenheart is imported in logs from the West Indies, and there is considerable waste in framing the timber. There is nothing in connection with the gates which affords an example for construction in this country. In a recent discussion at the Institute of Civil Engineers on the question of lock gates, it was remarked by a competent authority that it was curious to observe how some engineers adopted iron and some wooden lock gates. At the Alexandra Docks, at Hull, wooden gates are employed; at the Barry Docks, iron gates. At Liverpool, wooden gates; at Havre there were formerly wooden gates across the big entrance (100 feet wide) of the Eure Dock; but for these iron gates have been substituted. Although, it seems as if the general verdict were in favour of wooden gates, it appears strange that those on the Manchester Ship Canal, which runs through a county of iron manufactures, should be built of wood imported across the ocean at great expense. As to their being less liable to damage than iron gates, it is to be feared that if a large vessel strike either, the result would be about the same. On the Welland and St. Lawrence Canals, the solid gates which have been some time in use have given fair satisfaction, although a weak form of construction. For high lifts, gates built on the plan of those of the American Sault Ste. Marie Canal have the materials scientifically distributed to meet the strains; and in practice they have given much satisfaction. The frames are of oak sheathed with Norway pine, and strengthened with iron bolts and straps where necessary, so as to combine lightness with strength. A leaf of the Lower lock gates weighs 76 tons. A modification of these gates to suit the circumstances of each case would form a very good type for use in the completion of the St. Lawrence Canals.

The machinery for operating the heavy gates and sluices of the Ship Canal is correspondingly heavy and expensive. The Armstrong hydraulic apparatus, now being constructed at Eastham, is only partly executed, and its ultimate cost could not be obtained. This system is in use to a considerable extent at the Liverpool docks, where it is found to answer admirably. It was said that the cost of building and machinery at Eastham alone would be over £50,000, and at the other four sets proportionately expensive. In the statement given of the extra sums granted to the contractor by the arrangement of the 24th November, 1890, previously referred to, an item of £36,104 appears for "additional work on the Armstrong contract." It seems probable that the cost of buildings and machinery to operate all the lock gates, &c., would be at least £250,000. The interest on this would be about \$62,500 yearly, to which the cost of fuel, attendance and operators on the lock must be added. This would place such a system quite beyond our means for anything but an isolated lock like that at Sault Ste. Marie. The machinery of the new American lock there is estimated to cost \$100,000, and the annual expenditure for operation cannot be less than at the present one, viz., over \$30,000. It seems, therefore, clear that the hydraulic system could not be judiciously adopted on a canal with numerous locks, but it is probable that machinery for the purpose may soon be very much simplified; and both its first cost and that of operation greatly reduced by the introduction of

electrical apparatus, especially where there is sufficient water power available in the vicinity. On the Ship Canal steam is used at Eastham to pump water into an accumulator from whence it is distributed at high pressure all over the locks in pipes to wherever the power is required. This is applied to the purpose of opening and shutting the gates much in the same way as at Sault Ste. Marie, but an improvement is made by having the chains work from a fixed point in the lock wall as will be seen on examining the plans. At the Sault the driving power is the fall at the lock, as there is no need of economising water, such as exists on the Ship Canal.

In reference to this matter, it may be said that the most recent application of hydraulic power to the operation of gates is at Barry Docks, South Wales, where pistons connected with rams placed in recesses behind the gates are applied to fixed points in their rear. These pistons, the stroke of which is over 26 feet, push the gate shut, or pull it open as required, and this is performed with great steadiness, even when there is a very rough sea. This is a manifest improvement on the complicated system of sheaves and chains of the Armstrong plan and has received the warm approval of many distinguished English engineers. Electric motors could be used to effect the object somewhat after this fashion, lock gates of the size of those on the St. Lawrence navigation could be worked with great ease and expedition. The subject is one well worthy of close attention.

It has been previously observed that all the lock and dock walls are almost entirely built of concrete, the amount of which used on the Ship Canal will be about 1,250,000 cubic yards. Its preparation is conducted in a very simple and apparently quite efficient way, by ordinary labour for the most part; but the greatest care is taken in the selection and treatment of the materials of which it is composed, and from which such very satisfactory results have been secured.

As to the cement—this has been obtained from various manufacturers, but it is all subjected to the same tests. It would take too long to describe these in detail, but it may be said that where so much depends upon the purity of the article, its quality is assured by the most rigid examination and trials. A cement must not only stand a certain maximum breaking strain at a definite period shortly after setting, but it must show a considerable increase of strength in time. For example, suppose an inch section breaks at the end of seven days at 300 lbs., then it is made imperative that the same section shall be made to stand, say 375 lbs. in twenty-eight days afterwards. Then, as regards the essential quality of fineness, this must also be thoroughly satisfactory. In brief, the progress of science and improved methods of manufacture have clearly shown that risks of failure, hitherto deemed inseparable from the use of Portland cement concrete, are really attributable either to the fact that the cement has been badly made, or that proper care has not been exercised in the preparation of the aggregate, to ensure which only ordinary precautions are required.

The greater part of the concrete used in the Ship Canal is formed of gravel, sand and cement in the proportion of 8 to 1 by volume. In the face work 4 to 1 is used. The aggregate is thoroughly mixed on a platform—then a sufficiency of clean water is added through the rose of a watering pot, and the whole well turned over when wet. It is then wheeled from the platform on runs and dumped on the wall from the barrow. This is all that is necessary to insure an excellent job. Miles of walls made in this way were carefully examined by the writer, and no change was visible in any part of them, although last winter's frosts in England were, as is well known, exceptionally severe.

There may, of course, be positions in which, for economical reasons, rubble masonry might be preferable to concrete; but the manifest facility and cheapness with which a hydraulic wall can be built of this material—the ease with which it can be moulded into any required shape, thus often avoiding costly cutting—and the fact that but a short training is required to enable an ordinary labourer to prepare it, are obviously strong arguments in favour of its more general adoption on the hydraulic works of Canada. On the Ship Canal the filling culverts through the lock

walls previously alluded to were intended to have a lining of bricks throughout, but they are now simply faced with richer concrete, and the brick lining has been dispensed with as unnecessary.

A most instructive example of the adoption of concrete as a building material in our climate, and under the most disadvantageous conditions, is afforded by the recent renewal of a considerable portion of the breakwater at Buffalo Harbour, the wooden superstructure of which had been more or less destroyed by the violent gales so prevalent on Lake Erie.

The question of the advisability of abandoning the old method of renewing wooden superstructures with the same perishable material, and in view of the greatly increased price of timber, has been frequently discussed. It has been proved that even supposing the life of the latter to be fifteen years, it would pay to rebuild in stone or concrete. It therefore becomes a matter of considerable importance as to which is the better plan to adopt. In the case in point, two modes were submitted. One was to renew the superstructure with a hearting of concrete faced with cut stone. The other was to make the whole of concrete; the interior portion to be of native cement, and the outer four feet all round and on top to be formed of Portland cement concrete. The first plan was, after a short time abandoned, because of the great cost of the masonry, and also for the reason that the experience obtained led to the conclusion that concrete alone was sufficiently strong and durable to withstand successfully the attack of storms which had destroyed the wooden superstructure.

The officer in charge of the work reported that in May, 1888, a careful examination of the new concrete work was made after the ice had left Lake Erie, and though the preceding winter had been exceptionally severe, no damage was done, and the surface of the concrete had undergone no perceptible degradation. It was then recommended that the further use of masonry should cease; and as a matter of fact there were only 228 cubic yards of cut stone built, although it required about 15,500 cubic yards of concrete to renew 1,450 in length of superstructure. In this case the cut stone cost nearly six times as much as the concrete, but the price of neither can be taken as a fair criterion for work done under ordinary circumstances. There were many interruptions owing to its exposed position, and the frequent occurrence of stormy weather, besides the extra expense attendant upon its being out of the reach of ordinary means of transport. The engineer has recommended that a further length of 2,000 feet of pier be renewed on the same plan which has proved quite satisfactory.

The late Chief Engineer of Canals, Mr. Page, also had a test made of this material with a view to using it for the purpose above described; but in a much more sheltered position. A length of some 400 feet of the east pier at Port Dalhousie Harbour, the wooden superstructure of which was quite decayed, was rebuilt of concrete, the cross-sectional dimensions of which are about 18 feet by 5 feet. It has resisted perfectly the action of frost and has in every way proved suitable for the intended purpose. Means are not at hand to get at the particulars of its preparation or cost, but these can doubtless be had from the officer in charge. It may be said, however, that the work being only an experiment (and confessedly so) would likely prove more costly than if a large quantity had been done and the proper experience acquired. Opinion is divided as to the propriety of mixing native and Portland cements together, but it seems to be generally in favour of the use of the latter only where the best results are required.

From the foregoing, it would appear that extensive experience, both English, American and Canadian, point to the conclusion that Portland cement concrete, if made of sound material and with proper care, can be safely used in hydraulic works and in exposed positions in this climate, and that the question of its durability has ceased to be a matter of doubt or conjecture.

Another point in connection with the Manchester Ship Canal which merits special mention is its sluices on Stoney's Patent, which are introduced throughout in

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the locks and weirs or wherever water has to be controlled. These sluices are an excellent invention, and may be briefly described as wrought iron shutters or doors moving vertically in grooves formed in the masonry piers of the weirs, etc.,—and carried on live rollers so arranged as to almost eliminate friction, so that with the use of the counterbalance they can be operated by hand power with surprising ease.

It is obvious to any one who has had practical experience of the troubles arising from the use of some of the existing valves on our canals that simplicity of form is a great recommendation, for nowhere is this more valuable than in connection with the regulation and control of water on a line of navigation. Complicated valves, almost impossible to work satisfactorily and as easy to be damaged as they are difficult to repair, should be done away with and the principle of the Stoney sluice introduced in their stead.

The plan attached will show the details of the gates, roller frames, water tight joints, etc., which it would be impossible to describe here. The great merits of this invention are now universally recognized. The sluices are especially adapted for controlling large bodies of water, but can also be as advantageously applied to the purposes of lock and culvert valves. It is obvious that there is a great advantage in having a completely unobstructed opening secured in the way shown. Logs, sticks or other floating bodies which would jam in the valves of an ordinary weir built as at present with numerous small submerged openings, could pass freely through the spaces between the piers of the Stoney sluice. In these the shutters are made to run up to such a height as to be entirely clear of the surface of the water, and thus give perfectly free openings of 30 feet wide of the full depth required, which would not have been practicable, except by an application of the principle carried out in Stoney's patent.

Where the Ship Canal crosses the embayment at the mouth of the River Weaver, there is a large weir (previously referred to) having ten of these sluices with an aggregate width of 300 feet. The details of this fine structure are well worthy of attentive study in connection with the completion of our canal system, especially on those portions where the work of construction has not yet been commenced and where arrangements can readily be made for the reception of these sluices with modifications suitable to the circumstances of each particular case. The wisdom of adopting them so generally on the Ship Canal, will be abundantly evident on examining the series of photographs forwarded herewith, which were taken immediately after the last floods; and show what provision is necessary to prevent disaster when the line of navigation is opened for traffic.

Attention is drawn to the accompanying printed document for further details on the construction of these sluices, which will be found very interesting. It contains evidence given by engineers before the Judicial Committee of the Privy Council in favour of the renewal of the patent. In this connection it may be said that there is no reason why the sluices could not be manufactured in Canada from the plans now submitted; but in fairness to the patentee, who has devoted many years and much labour to the whole subject before bringing his invention to its present state of perfection, he should be called upon, in case his sluices are adopted on any of our public works, to supply the detailed plans and estimates of them; and, if considered necessary, send some competent engineer or mechanic here to superintend their erection on his behalf.

As previously stated the drainage of the country will, above Latchford, be effected by the canal, but on its tidal portion some streams are passed under the canal, the principal one being at the River Gow. The culvert for this is a considerable structure, and consists of two cast iron tubes of 12 feet diameter each. These are built of segmental plates fitted together and bolted at the joints. The body of the plates is 1 inch in thickness, the edges being strengthened by feathered ribs. The tubes are bedded in concrete, and their tops are placed about 4 feet below canal bottom to permit of subsequent deepening. Their ends are formed of concrete walls and wings, and the channels of approach are about 35 feet wide at the bottom,

their sides being protected with heavy stone pitching. The bottom of this culvert, where it passes under the Ship Canal, is fully 50 feet below the surface of the ground adjoining. The material excavated appears to have been very soft clay and considerable trouble was experienced in getting a proper foundation, especially at such a depth below tide-water. The length of the siphon is 360 feet.

At periods of high water in the Mersey the water will rush through these tubes into the valley of the river or creek, and flow out with the receding tide. This form of culvert has been adopted in view of its efficiency and cheapness. The tubes can, of course, resist pressure in either direction, and in that respect (amongst others) have a manifest advantage over masonry arches. Steps have been taken to preserve the inside surfaces from the corrosive action of salt water. No difficulty is, however, apprehended in connection with these tubes; although when once filled they will be difficult to unwater; nor does there appear to be any reasonable grounds to doubt their fully and efficiently answering the intended purpose.

As regards the proportion of work remaining to be done and the time necessary for completion, it may be stated that three-fourths of the excavation was taken out up to February last; so that at the rate of progress previously attained it should be completed in twelve months. It must be borne in mind, however, that there are some very difficult portions yet untouched, as for example the long gap in the embankment between the Weaver and Runcorn. These banks where they approach upon the sands of the Mersey have already given a great deal of trouble and will probably give more. The locks for the Bridgewater, Weaver and Runcorn Canals are situated at this point, and in the vicinity there has been considerable subsidence, large quantities of material having been swallowed up before a foundation was obtained. There are also certain parts in the interior between Latchford and Manchester in the earthwork sections yet remaining, where there will be trouble again from water. But the various locks, sluices, &c., from Eastham to Mode Wheel are in quite an advanced stage. At Eastham the gates were partly set up and the machinery for their operation was being fitted in place. Nearly all the dock walls at Salford are built and a large amount of work is done in that vicinity.

The railway viaducts and approaches are well advanced. Some of these structures are very costly, but as they are not directly connected with the question of navigation—being fixed at a certain height over the canal—no special examination was made of them.

The Stoney sluices were in place at Eastham and "Old Randles," and in progress at other places. Some of the road bridges were in process of construction. These are very considerable structures, the long arm of those made to swing having a span of 120 feet. During the examination the works presented at many places an extraordinary appearance owing to the action of floods, which has torn up the railway tracks laid in the bottom of the canal, upset the steam shovels, waggons, &c., and burst through the dams in many places, filling long sections of the incomplete prism with water which had to be pumped out before operations could be resumed. Below the locks at Latchford the water rose upwards of forty feet—and for miles the canal looked as if it were ready for navigation. But notwithstanding these drawbacks, there is no reason why, if the necessary funds are forthcoming in time as they doubtless will be, that the canal throughout should not be opened for traffic next year. There will probably be some trouble in excavating a channel of approach at the lower entrance and keeping it clear afterwards. There is much uncertainty about all such channels, and those amongst the shifting sandbanks of the estuary of the Mersey, are, it is said, constantly changing. The main shore below Eastham is, however, rocky, and the channel chosen for leading to the entrance to the canal, has, it is understood, preserved its present dimensions for a long period.

It is difficult, however, to understand how large vessels will be able to safely enter the Eastham locks when borne along on the tidal current to the mouth of the

canal, but it is presumed that the experience gained at the Liverpool docks, where vessels have to enter quickly from the river during high water, will enable ship captains to guide their crafts safely in what seems to be a dangerous place. It appears as if it would have been an excellent thing to form a large basin just above the group of locks at Eastham, where vessels could halt before starting up the canal. It is to be hoped, however, that all the benefits expected to flow from the construction of this great work will eventually be realized. The Ship Canal is expected to begin business with a tonnage of about four and a half millions. This figure (although large) is only about half that now passing through the Sault Ste. Marie, which is increasing at the rate of over a million and a quarter tons per annum. In one month (June, 1890), 1,413,001 tons of freight passed through the lock, and its full capacity may be reached before the Canadian canal, now in progress, can be built. The tonnage which passes Detroit, represents the trade of Lake Michigan in addition to that of Superior, and is over 20,000,000 (twenty millions) tons per annum. This shows the enormous proportions to which the lake traffic has grown, and the cheapness of water transport is sufficiently evident from the fact that wheat is being carried this season from Chicago to Buffalo, a distance of about one thousand miles, at a rate of one cent per bushel.

In conclusion, it may be said that the general impression formed of the Manchester Ship Canal, is that of a magnificent line of navigation, the works of which have been most substantially executed, but whose free operation will be somewhat trammelled by its having to act as the main drain for a large country at one end, and be embarrassed by the unfortunate necessity of admitting tide water at the other.

A large number of plans, pamphlets, photographs, &c., are sent in herewith. This report would, doubtless, be better understood if some of these were reduced, and printed as illustrative of the text.

Special thanks are due to Mr. W. H. Topham, the general manager for the trustees of the Walker estate, who supplied a large amount of information on which this report is based, and also to Mr. A. O. Shenck, the chief engineer for the contractors, who most willingly gave all the technical data in his power at a time when he was fully occupied in preparing estimates and other professional documents connected with the question of the additional amounts of money which it would be necessary to raise beyond the original estimate, in order to insure the full and satisfactory completion of the Ship Canal. Finally, it is hoped that the above rapid and necessarily incomplete review of the principal matters connected with this magnificent enterprise may be of service in drawing attention to those points upon which further and more detailed information seems desirable.

Respectfully submitted,

THOMAS MONRO,

M. Inst. C. E., &c.

To A. P. BRADLEY, Esq., Secretary, Department Railways and Canals, Ottawa.

APPENDIX.

STATEMENT made of the amount of additional expenditure not contemplated when the contract was arranged.

Requirements of the Mersey Conservancy at Eastham	
Locks.....	£219,017
Railway and canal companies, additional.....	68,300
Lengthening slip at Ellesmere Port.....	10,625
Deviation railways, additional.....	79,951
Vyrmy waterworks sub-way (Liverpool).....	6,722
Landowner's requirements.....	29,964
Additional work.....	39,581
Docks and straightening canal at Barton.....	154,000
Extras on Armstrong's contract.....	36,104
Flood sluices	11,048
Extra cost of materials, concrete.....	£ 99,688
Stone	40,760
Substitution of brick work for masonry rubble.....	69,813
	———— 210,261
	£865,573

Land expenses.....£1,022,390

(Extract from speech of chairman at meeting of 4th February. 1891. at Manchester.)

LIST of Firms who have supplied Excavators, Locomotives, Cranes, &c., for the works of the Manchester Ship Canal.

Excavators.—Ruston, Proctor & Co., Sheaf Iron Works, Lincoln. J. H. Wilson & Co., Sandhills, Liverpool. Whitaker Bros., Horsforth, near Leeds. Boulet & Co., Rue Bained 31—Paris. Lubecker Machine Co., Germany. Priestman Bros., Holderness Foundry, Hull.

Locomotives.—Manning, Wardle & Co., Boyne Engine Works, Leeds. Hunslet Engine Co., Hunslet, near Leeds. Hudswell, Clarke & Co., Railway Foundry, Leeds.

Pile Engines.—Sissons & White, Hendon Road, Hull. Whitaker Bros., Horsforth, near Leeds.

Lathes and Drilling Machinery.—Butterfield & Co., Midland Works, Keighley.

Hydraulic and other Jacks.—Tangyes, Limited, Deansgate, Manchester. Ward & Sons, Broad Street, Birmingham. Gowdy & Co., 400 Queen Street, Cannon Street, London, E.C.

Lamps, Lights, &c.—A. C. Wells & Co. (Well's Lights), Carnarvon Street, Cheetham, W. C. Cowdy & Co. (Engine Lamps), 40 Queen Street, Cannon Street, London, E.C.

Cranes.—Thomas Smith, Old Foundry, Rodley, near Leeds. J. H. Wilson, & Co., Sandhills, near Liverpool. Butter Bros. (for Derricks), 20 Waterloo Street, Glasgow.

Portable and Stationary Engines and Boilers.—Ruston, Proctor & Co., Sheaf Iron Works, Lincoln. Ransom's, Sims & Jeffries, Orwell Works, Ipswich.

Pumps.—J. A. Wade, Patent Tile Works, Hornsea, Hull. Ruston, Proctor & Co., Sheaf Iron Works, Lincoln. Tangyes, Limited, Deansgate, W. C. Bailey, W. H. & Co., Oldfield Road, Salford.

TABLES SHOWING RELATIVE COST OF TRANSPORTATION.

(1.) PRESENT COST of Transit of various Articles from ex-Ship, Liverpool to Railway Station or Canal Wharf, Manchester.

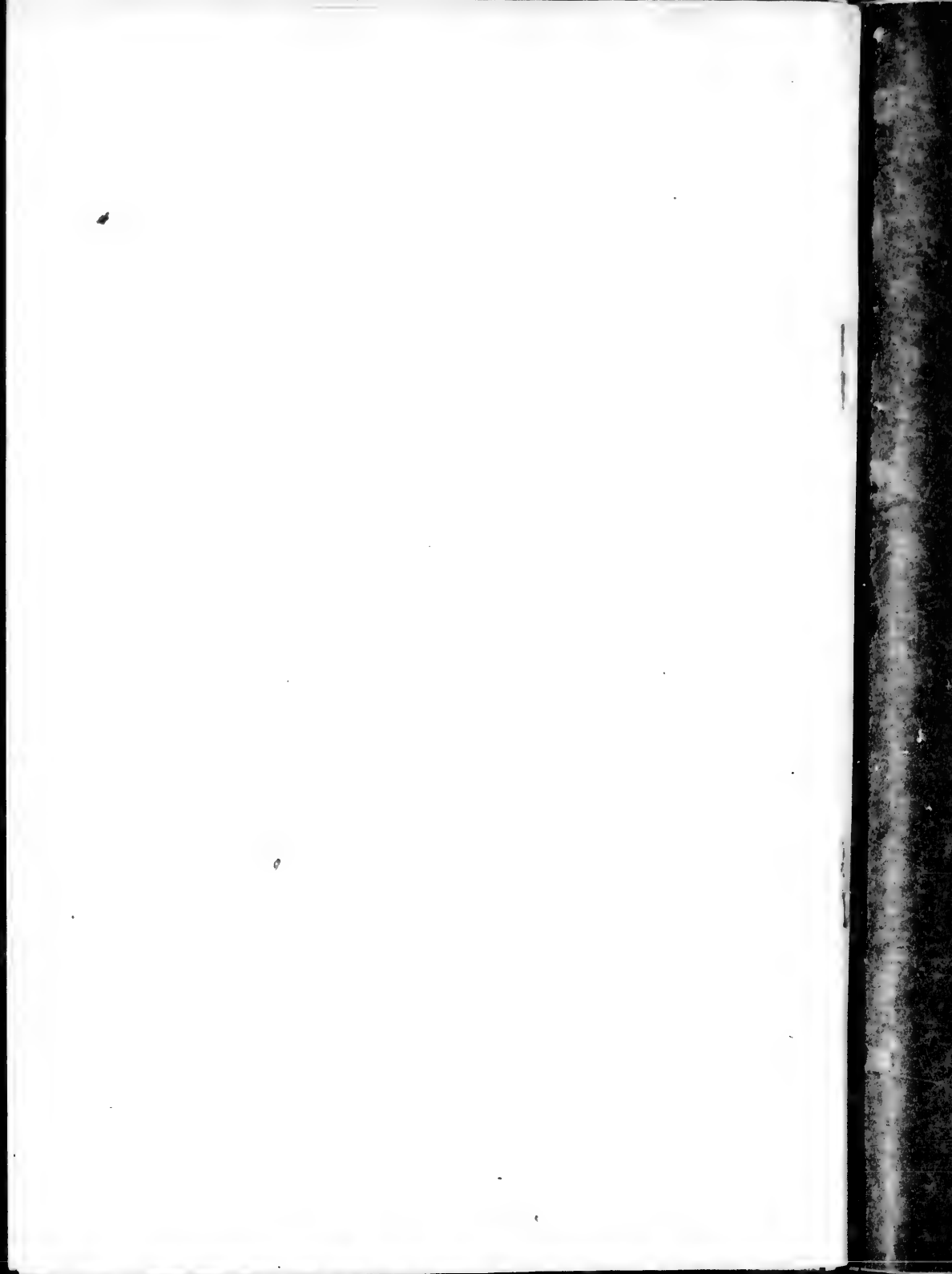
Articles per 20 Cwt	Dock and Town Dues.	Master Porterage.	Quay Attendance.	Carting to Rail or Barge.	Railway or Canal Carriage.	Total per Ton.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Cotton.....	3 0	1 3	1 0	1 3	7 2	13 8
Wool.....	3 6	1 6	1 0	1 3	9 2	16 5
Sugar, leaves.....	3 0	1 10	1 0	1 3	10 10	17 11
do unrefined.....	2 1	1 2	1 0	1 3	6 8	12 2
Bacon and hams.....	2 2	1 5	1 0	1 3	9 2	15 0
Tinned meats.....	4 0	2 0	1 0	1 3	9 2	17 5
Tea.....	2 6	2 7	1 0	1 3	10 10	18 2
Grain, wheat in sacks.....	1 4	0 8	0 3	1 0	6 8	9 11
Fruit, oranges.....	1 3	1 7	1 0	2 0	9 2	15 0
Petroleum.....	1 8	1 4	1 0	1 3	9 2	14 5
Tallow.....	2 3	1 1	1 0	1 3	7 11	13 6
Iron ore.....	0 3	1 2	0 1	1 3	4 2	6 11
Timber.....	1 0		1 9		6 8	9 5

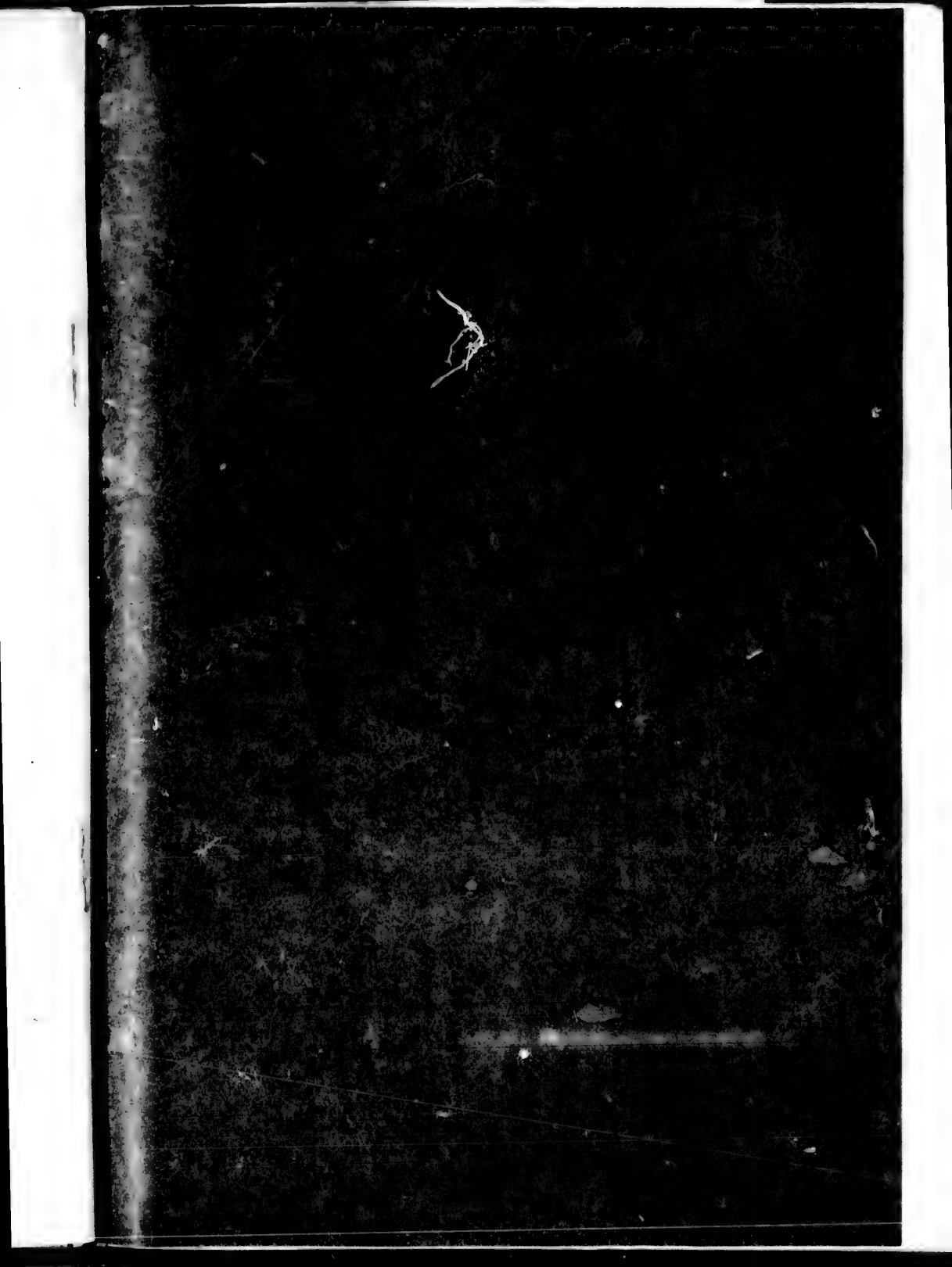
(2.) THE COST of bringing the same Articles to Manchester by the Ship Canal, including the Maximum Charges in the Bill.

Articles per 20 Cwt.	Canal Toll.	Landing Charges.	Wharfage.	Total per Ton.
	s. d.	s. d.	s. d.	s. d.
Cotton.....	4 3	1 0	1 9	7 0
Wool.....	5 0	1 0	1 9	7 9
Sugar, leaves.....	4 2	1 0	1 6	6 8
do unrefined.....	3 4	0 6	1 1	4 11
Bacon and hams.....	5 0	0 6	1 11	6 7
Tinned meats.....	5 0	1 0	2 0	8 0
Tea.....	5 10	1 6	1 3	8 7
Grain, wheat in sacks.....	3 8	0 6	0 8	4 10
Fruit, oranges.....	5 0	0 6	0 8	6 2
Petroleum.....	4 7	0 6	0 10	5 11
Tallow.....	4 2	0 6	1 2	5 10
Iron ore.....	2 1	0 6	0 3	2 10
Timber.....	3 9	0 6	9 6	4 9

(3.) COMPARISON of the Total Charges in No. 1 and No. 2, showing Total Savings by Canal.

	Cotton.	Wool.	Sugar (Leaves).	Sugar (Raw).	Bacon.	Tinned Meats.	Tea.	Wheat.	Oranges.	Petroleum.	Tallow.	Iron Ore.	Timber.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Present cost....	13 8	16 5	17 11	12 2	15 0	17 5	18 2	9 11	15 0	14 5	13 6	6 11	9 5
Cost by Ship Canal.....	7 0	7 9	6 8	4 11	6 7	8 0	8 7	4 10	6 2	5 11	5 10	2 10	4 9
Saving per ton.....	6 8	8 8	11 3	7 3	8 5	9 5	9 7	5 1	8 10	8 6	7 8	4 1	4 8





BIRKENHEAD

LIVERPOOL

*Copy of Plan handed to me
at Manchester, 30th January, 188*

Liverpool

HALEWOOD
Liverpool, Warrington

Liverpool, Warrington and Garston
Railway

GARSTON

EASTHAM FERRY.

EASTHAM
Eastham Locks (Tidal)

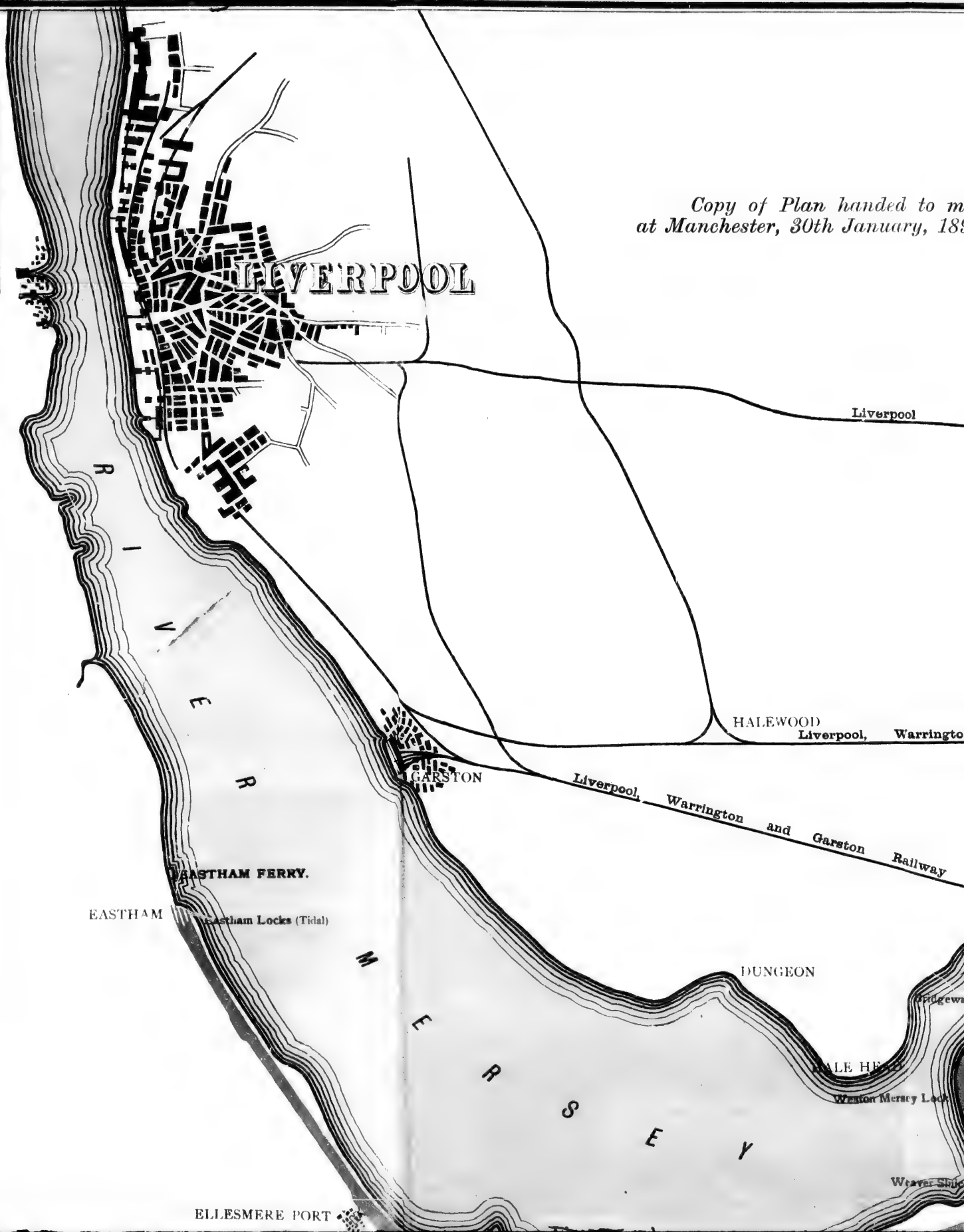
DUNGEON

HALE HERR

Wenton Mersey Lock

Weaver Ship

ELLESMERE PORT

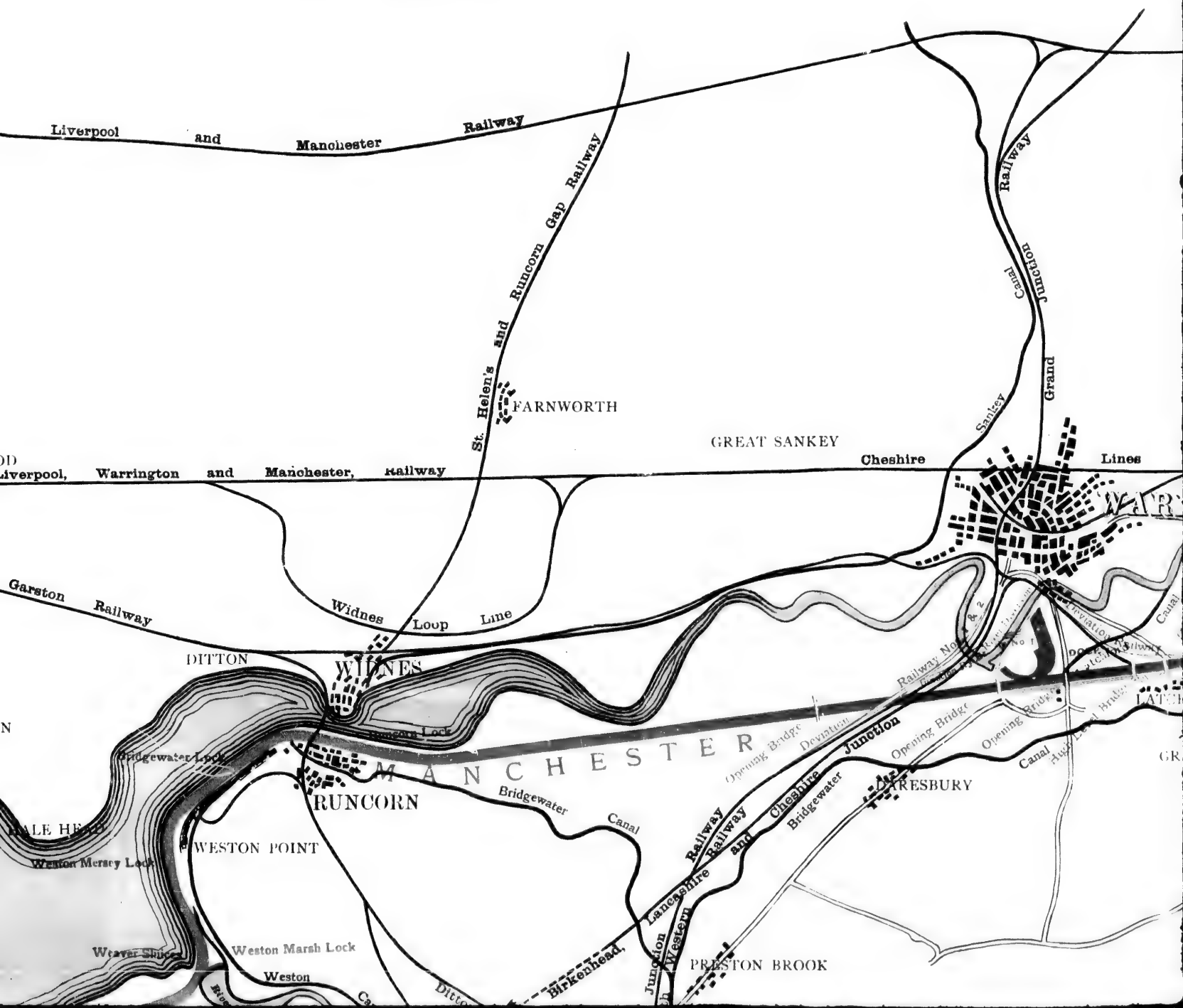


MANCHESTER

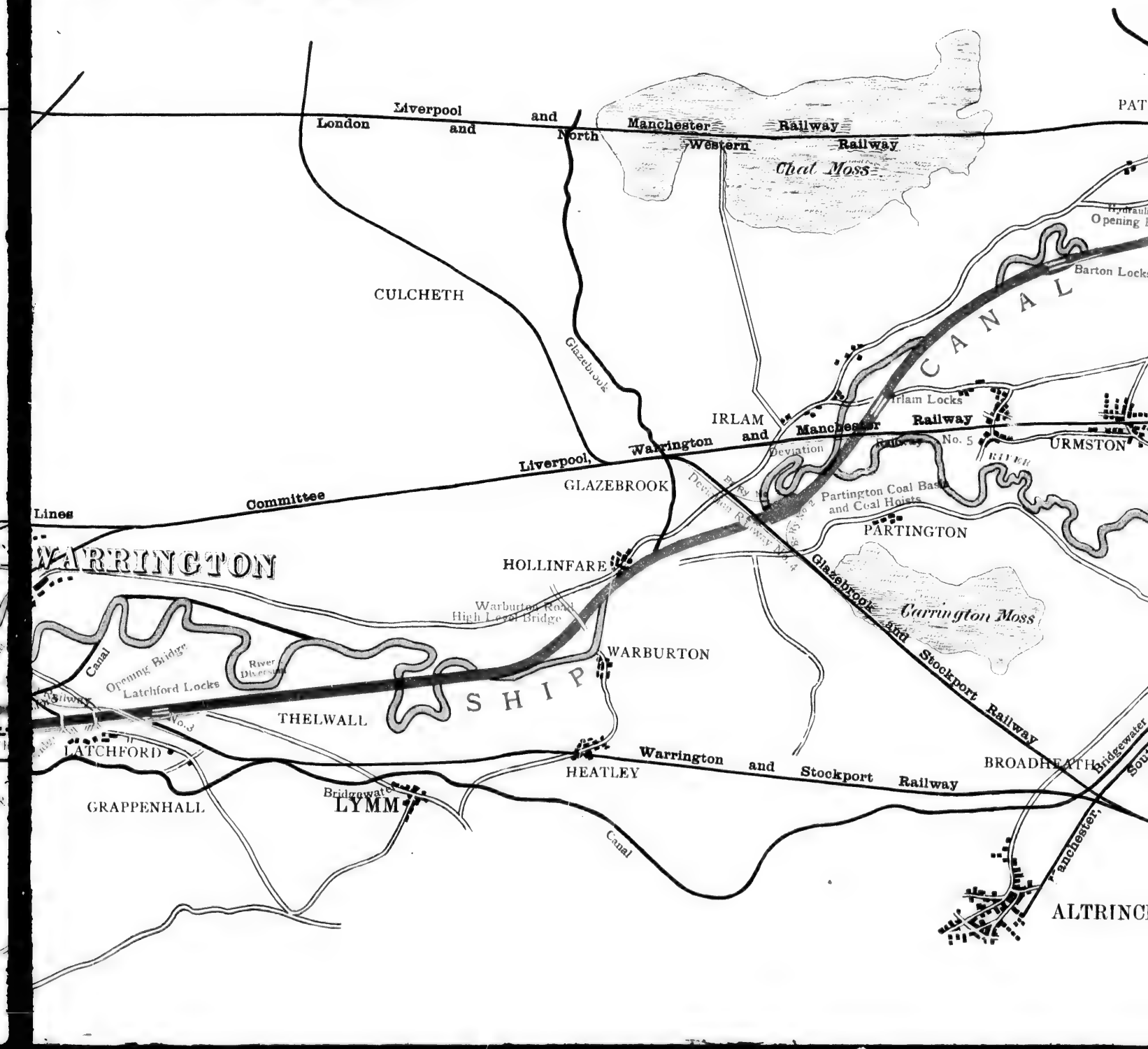
GENERAL

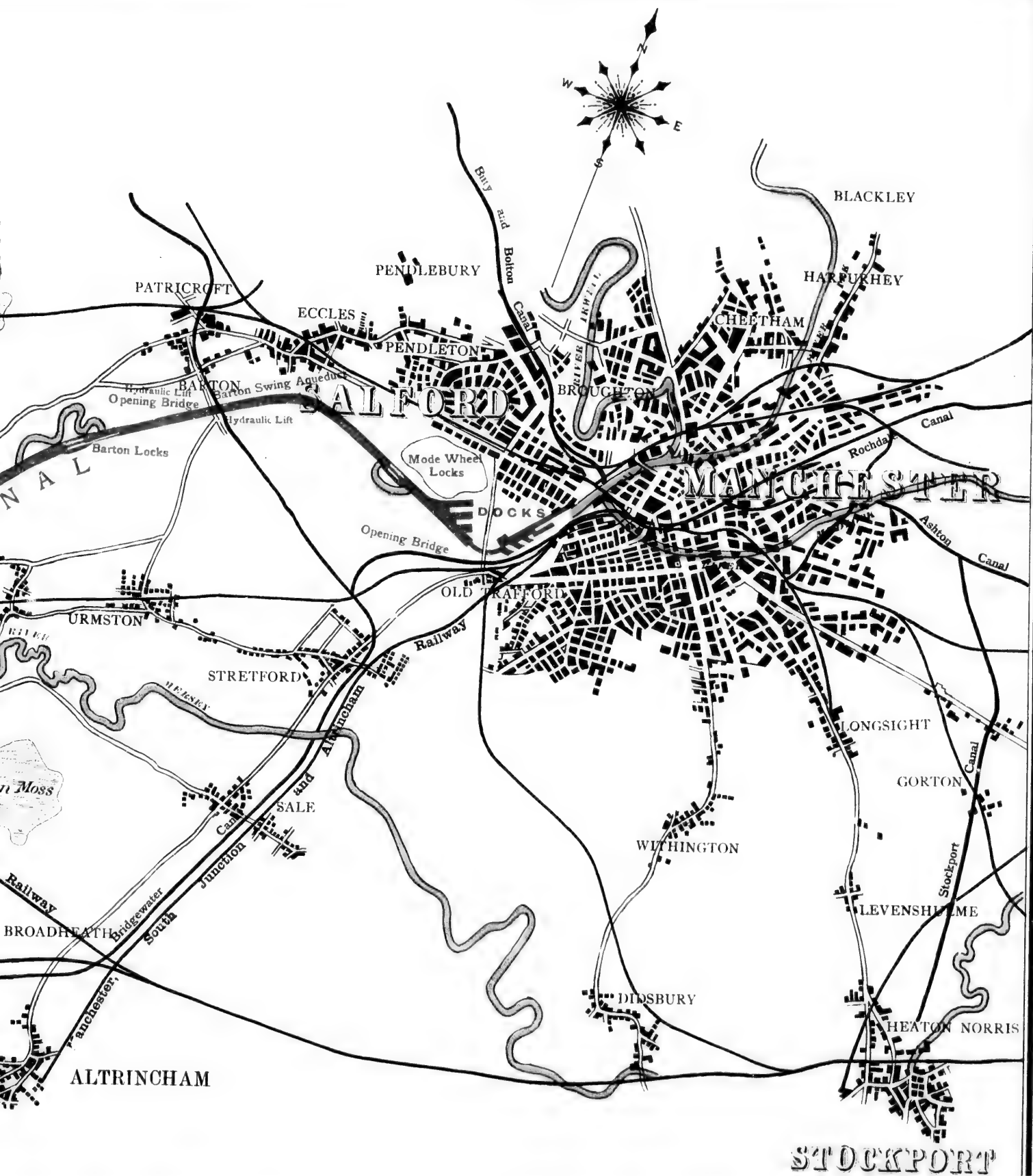
an handed to me by Mr. E. Leader Williams,
0th January, 1891.

THOMAS MONRO,
M. Inst. C. E.



SHIP CANAL AL PLAN.





ELLESMERE PORT

River
Gow

Holpool
Gutter

Wear

MANCHESTER AND SALFORD DOCKS.

AREA OF WATER SPACE 114 ACRES
LENGTH OF QUAYS 5¼ MILES.
AREA OF QUAY SPACE 152 ACRES.

WARRINGTON DOCK.

AREA OF WATER SPACE 23 ACRES.
QUAY FRONTAGE 1¼ MILES.

*To accompany Mr. E. Leader Williams Paper read at the
4th International Conference on Inland Navigation.*

EASTHAM LOCKS (Tidal)

NO.	FT.	FT.			
1	600	X	80	RISE FROM MEAN	FT. IN.
2	350	X	50	TIDE TO ORDINARY	9 8
3	180	X	80	WATER LEVEL	

ELLESMERE PORT

RIVER GOW

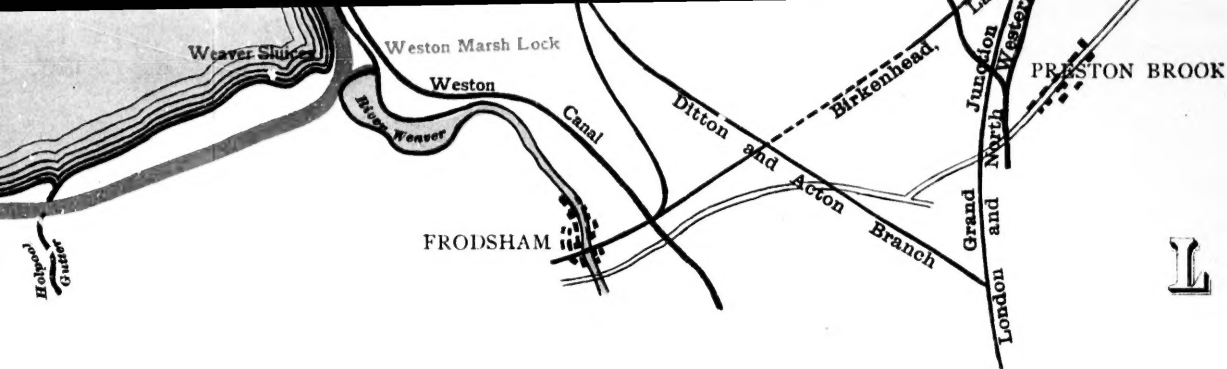
HOLPOOL GUTTER

LEVEL OF HIGH WATER OF EQUINOCTIAL SP

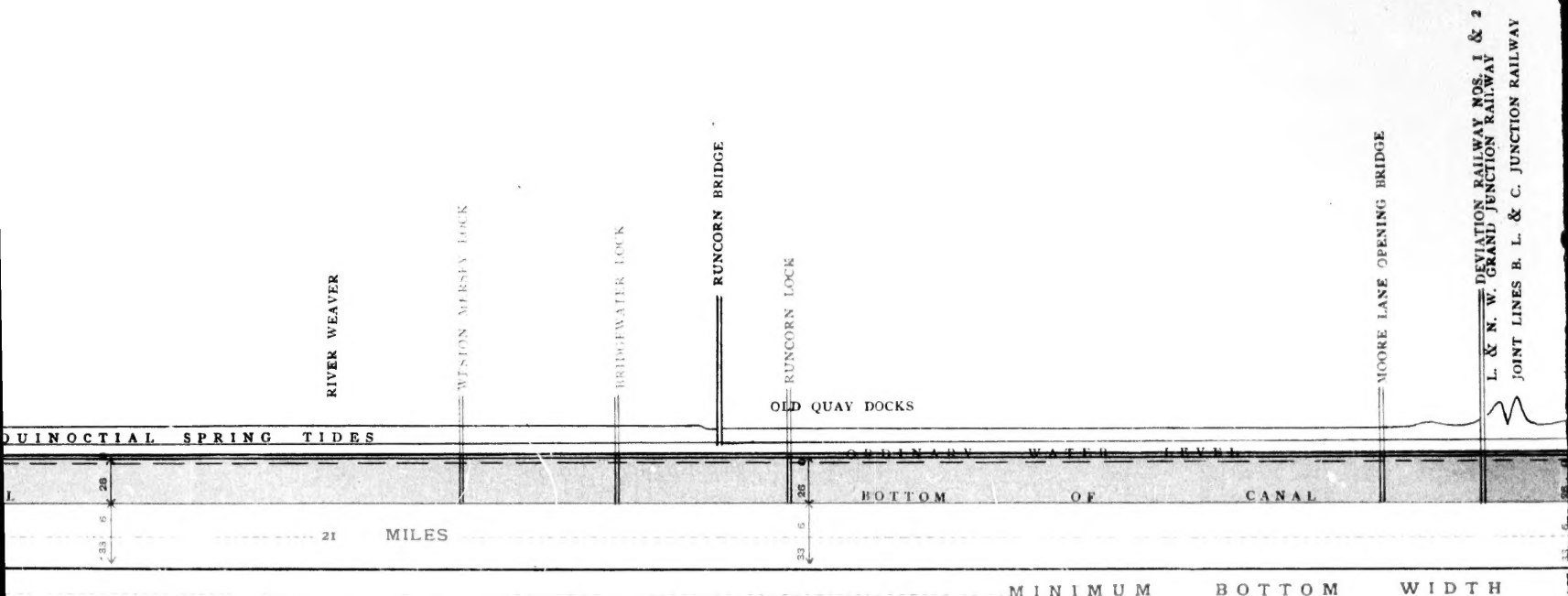
BOTTOM OF CANAL

LWL

Manchester Ship Canal Datum



L O N G I T U

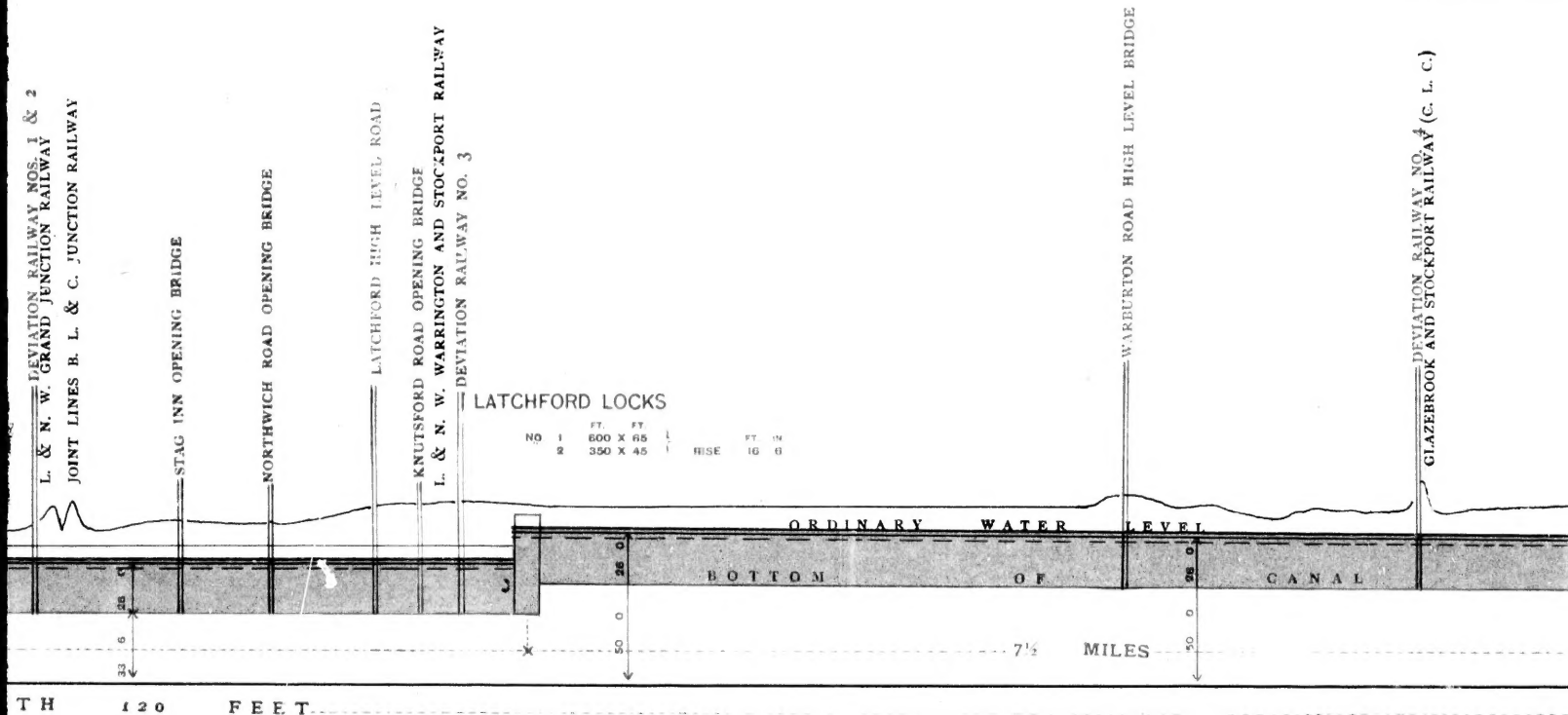


DEVIATION RAILWAY NOS. 1 & 2
L. & N. W. GRAND JUNCTION RAILWAY
JOINT LINES B. L. & C. JUNCTION RAILWAY

10 0
FEET

T U D I N A L S E C T I O N

Scale of
MILE 1 1/2 0
FEET



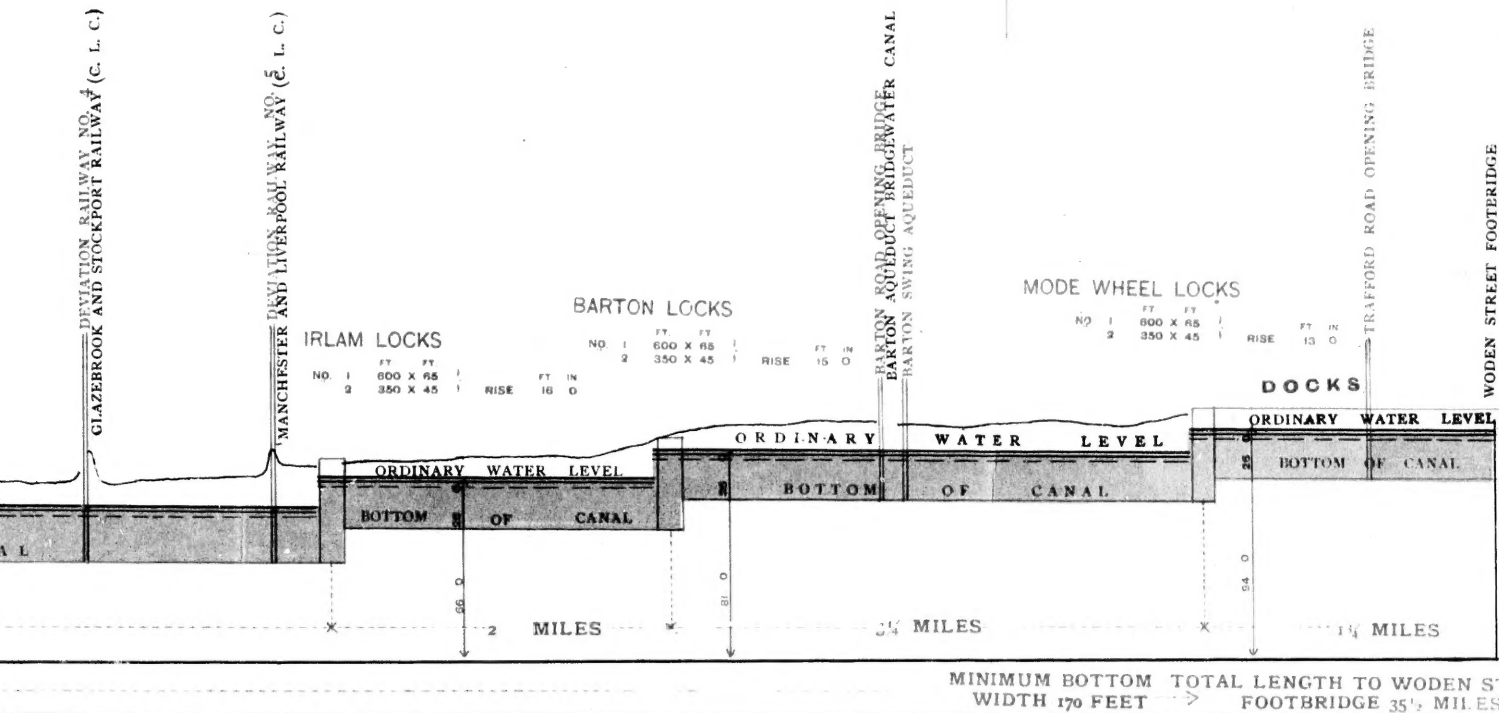
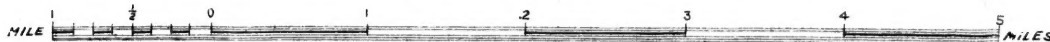
STOCKPORT

Vertical Scale for Section



Engineer's Office,
Manchester Ship Canal,
Manchester, July, 1890.

Scale for Plan and Horizontal Scale for Section



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